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09/551,233	04/17/2000	Katsuyoshi Matsuura	FUJ 99228 CIP	9686

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EXAMINER
LEE, HSIEN MING

ART UNIT	PAPER NUMBER
2823	

DATE MAILED: 05/30/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 09/551,233	Applicant(s) MATSUURA ET AL.	
	Examiner Hsien-Ming Lee	Art Unit 2823	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *25 April 2003* .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1,2,4-12,14-19 and 21-28* is/are pending in the application.

4a) Of the above claim(s) *4* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1,2,5-12,14-19 and 21-28* is/are rejected.

7)☒ Claim(s) *4* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Remarks

1. The RCE request filed 4/25/03 is acknowledged.

2. Claims 1, 2, 4-12, 14-19 and 21-28 are pending in the application. Of the above, claim 4 is withdrawn from the consideration for the reason as follow.

Claim Objections

3. Claim 4 is objected to under 37 CFR 1.75(c), as being of improper dependent form for failing to further limit the subject matter of a previous claim. Applicant is required to cancel the claim(s), or amend the claim(s) to place the claim(s) in proper dependent form, or rewrite the claim(s) in independent form. The limitation " said non-oxidizing gas.....", as recited in claim 4, has been *deleted* from base claim 1. Therefore, claim 4 is *withdrawn* from the consideration.

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

5. Claims 1, 2, 5, 6-10 and 14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Cuchiaro et al. (US 6,165,802) in view of Chivukula et al et al. (US 6,146,905).

In re claims 1, 2, 5, 6, 8-10 and 14, Cuchiaro et al. in Figs.1-5 and related text teach the claimed method of fabricating a semiconductor device having a ferroelectric capacitor 118, comprising the steps of:

* forming an active device element 110 on a substrate 102 (Fig.1);

* forming an insulation film 114 over said substrate 102 to cover said active device element 110 (Fig.1);

* forming a lower electrode layer 120 of said ferroelectric capacitor 118 over said insulation film 114, wherein said lower electrode layer is formed on a Ti layer 116;

* forming an amorphous ferroelectric film of a PZT (perovskite structure) 122 on said lower electrode 120 as a capacitor insulation film of said ferroelectric capacitor 118 (Fig.1); and

* forming an upper electrode layer 124 on said ferroelectric film 122 (Fig.1), wherein said step of forming said PZT ferroelectric film comprises a single annealing (i.e. a rapid thermal process, step 226 in Fig. 2), conducted after the step of depositing said PZT ferroelectric film 122, for crystallizing said PZT ferroelectric film 122, said single annealing step being conducted in an oxidizing gas atmosphere (i.e. oxygen) (col.8, lines 20-30); the step of crystallizing is conducted by supplying oxygen controlled to cause an oxidation in the Ti atoms reached a surface of the lower electrode 120 from the Ti layer 116 due to the elevated temperature in the crystallizing step; and further oxidizing the PZT ferroelectric film 122 in an oxidizing atmosphere after crystallizing the PZT ferroelectric film 122 (col.8, lines 28-30) .

. Cuchiaro et al. do not literally use the "amorphous PZT" in the teachings. One of the ordinary skill in the art, however, would have recognized that the treated PZT film formed in step 224, prior to the crystallizing step 226, is an amorphous PZT. If the treated PZT film were not the amorphous PZT, then it would not be necessary to perform the rapid thermal step 226 for crystallizing.

In contrast, Cuchiaro et al. do not expressly teach that the atmosphere for crystallizing contains an oxidizing gas with a fraction of 1 to 20% in volume.

However, Chivukula et al. in an analogous art of forming PZT ferroelectric film teach crystallizing the PZT ferroelectric film in an oxidizing atmosphere containing O2/O3, wherein the O3 is an oxidizing gas and has a concentration in the range of 0.5 to 12% (col. 7, lines 6-10 and 29-35).

Therefore, it would have been obvious to one of ordinary skill in the art, at the time the invention was made, to utilize the oxidizing gas atmosphere of Chivukula et al in Cuchiaro's method, since by doing so it would provide a better ferroelectric performance and reduce film stress (col.7, lines 7-8 and 34-35).

In re claim 7, Cuchiaro et al. do not teach forming the PZT ferroelectric film by a sputtering processing. However, Chivukula et al. teach forming the PZT ferroelectric film by a sputtering processing. (col. 3, lines 43-46, Chivukula et al)

Therefore, it would have been obvious to one of the ordinary skill in the art, at the time the invention was made, to utilize the sputtering process of Chivukula et al for forming the PZT ferroelectric film of Cuchiaro et al., since sputtering process is a good candidate for forming a satisfactory PZT film.

6. Claims 11, 12, 15-19 are rejected under 35 U.S.C. 103(a) as being unpatentable over Cuchiaro et al. in view of Chivukula et al as applied to claim 1 above, and further in view of Chu et al. (US 6,287,637) and Izuha et al. (US 6,060,735).

In re claims 11 and 12, Cuchiaro et al. in view of Chivukula et al teach all limitations with the exception of crystallizing the ferroelectric film under a reduced total pressure (claim 11) in a range between 1 Torr and 40 Torr (claim 12).

However, Chu et al. in an analogous art of forming PZT ferroelectric film teach crystallizing the PZT ferroelectric film under a reduced oxygen partial pressure atmosphere (col. 6, lines 41-47) in the range of 10^{-4} to 100 Torr (col.7, line 28).

Therefore, it would have been obvious to one of the ordinary skill in the art, at the time the invention was made, to crystallize the PZT ferroelectric film under a reduced total pressure atmosphere within the claimed range as taught by Chu et al., in the method of Cuchiaro et al. in view of Chivukula et al, since by this manner it would produce the ferroelectric film with better performance and uniformity (col.6, lines 43-47,Chu et al.)

In re claims 15-19, Cuchiaro et al. in view of Chivukula et al teach the claimed device, comprising:

* a substrate 102;
* an active device element 110 formed on a substrate 102 (Fig.1);
* an insulation film 114 provided over said substrate 102 to cover said active device element 110 (Fig.1);
* a lower electrode layer 116/120 provided over said insulation film 114, wherein the lower electrode 116/120 comprises a Ti layer 116 and a conductor layer 120 (Pt);
* a PZT ferroelectric film (perovskite structure)122 on said lower electrode 120; and
* an upper electrode 124 provided on the PZT ferroelectric film 122 (Fig.1).

Cuchiaro et al. in view of Chivukula et al do not teach that the PZT ferroelectric film has a columnar microstructure extending from an interface between said lower electrode and said PZT ferroelectric film is in a direction substantially perpendicular to a principal surface of said lower electrode.

However, Izuha et al. (Figs. 1-7) in an analogous art teach the claimed semiconductor device, comprising a semiconductor substrate 1; a lower electrode 4 provided over the semiconductor substrate 1; a ferroelectric film 5 on said lower electrode 4 (Fig.1), said ferroelectric film 5 (perovskite structure such as PZT; col. 4, lines 52-53) having a columnar microstructure extending from an interface between said lower electrode 4 and said ferroelectric film 5 (Fig. 4A) in a direction substantially perpendicular to a principal surface of said lower electrode 4 (col. 2, line 57 through col.3, line 45), said ferroelectric film 5 essentially consisting of crystal grains having a generally uniform grain diameter of less than about 200 nm (col. 6, lines 52-53); and an upper electrode 6 provided on said ferroelectric film 5; wherein said lower electrode 4 comprises a Ti layer and a Pt layer (col. 4, lines 37-45).

Therefore, one of ordinary skill in the art, at the time the invention was made, would have been motivated to provide the semiconductor device of Cuchiaro et al. in view of Chivukula et al having a columnar microstructure in the PZT ferroelectric film extending from an interface between the lower electrode as taught by Izuha et al.; and the PZT ferroelectric film in a direction substantially perpendicular to a principal surface of the lower electrode with a reasonable expectation of success. The reason for that is that Cuchiaro et al., Chivukula et al and Izuha et al. have similar structure including a laminate film of the lower electrode, the ferroelectric dielectric and the upper electrode disposed in the order.

Still, Cuchiaro et al in view of Chivukula et al and Izuha et al. do not expressly teach that the PZT ferroelectric film generally has a <111> orientation and consists of crystal grains generally has the <111> orientation.

However, Chu et al. in an analogous art teach having PZT ferroelectric film and crystal grains with the <111> orientation in a semiconductor device would improve electrical characteristics of the device (col. 3, lines 47-55).

Therefore, one of ordinary skill in the art, at the time the invention was made, would have been motivated to provide the semiconductor device of Cuchiaro et al. in view of Chivukula et al and Izuha et al. having PZT ferroelectric film with a <111> orientation and consisting crystal grains with the <111> orientation, as taught by Chu et al., since by this manner it would provide a semiconductor device having better electrical properties.

7. Claims 21-28 are rejected under 35 U.S.C. 103(a) as being unpatentable over Cuchiaro et al. (US '802) in view of Chu et al. (US '637) and Chivukula et al. (US '905).

In re claims 21-25, 27 and 28, Cuchiaro et al. in Figs.1-5 and related text teach the claimed method of fabricating a semiconductor device having a ferroelectric capacitor 118, comprising the steps of:

* forming an active device element 110 on a substrate 102 (Fig.1);

* forming an insulation film 114 over said substrate 102 to cover said active device element 110 (Fig.1);

* forming a lower electrode layer 120 of said ferroelectric capacitor 118 over said insulation film 114 such that the lower electrode 120 is formed on a Ti layer 116 (Fig.1);

* forming an amorphous ferroelectric film of a PZT (perovskite structure) 122 on said lower electrode 120 as a capacitor insulation film of said ferroelectric capacitor 118 (Fig.1);

* crystallizing said amorphous ferroelectric film 122 by applying a rapid thermal process (step 226 in Fig. 2) (col. 8, lines 21-22) in an atmosphere containing an oxidizing gas such as oxygen (col. 8, lines 20-30); and

* forming an upper electrode layer 124 on said ferroelectric film 122 (Fig.1).

Cuchiaro et al. do not teach crystallizing the amorphous PZT film in an atmosphere containing a non-oxidizing gas and an oxidizing gas; and after the crystallizing step performing an oxidizing treatment in an oxidizing ambient.

However, Chu et al. in an analogous art teach steps of crystallizing the amorphous PZT in an ambient of non-oxidizing gas (Ar) and an oxidizing gas (O2) followed by oxidizing the PZT film (Figs. 2a-2d and col. 7, lines 14-16, 29-32).

Therefore, it would have been obvious to one of ordinary skill in the art, at the time the invention was made, to perform crystallizing and oxidizing steps as taught by Chu et al. in Cuchiaro's method, since by crystallizing in the ambient of Ar and O2 it would provide a better ferroelectric performance (col. 7, lines 37-40,Chu et al.); and by subsequent oxidizing it would fill the oxygen vacancies and complete the crystalline structure of the PZT film (col. 5, lines 44-46, Chu et al.).

Furthermore, Cuchiaro et al. in view of Chu et al. teach that the oxygen partial pressure is in the range of 10^{-4} to 100 Torr (col. 7, lines 25-28; col.8, lines 55-57; Chu et al.). With a small amount of the oxygen (col. 7, lines 11-16, Chu et al.) in the Ar/O2 ambient, it also inherently teaches that the oxygen (oxidizing gas) is within a fraction of 1 to 20% in volume.

In re claim 26, Cuchiaro et al. in view of Chu et al. do not teach forming the PZT ferroelectric film by a sputtering processing. However, Chivukula et al. teach forming the PZT ferroelectric film by a sputtering processing. (col. 3, lines 43-46, Chivukula et al)

Therefore, it would have been obvious to one of the ordinary skill in the art, at the time the invention was made, to utilize the sputtering process of Chivukula et al for forming the PZT ferroelectric film of Cuchiaro et al. in view of Chu et al., since sputtering process is a good candidate for forming a satisfactory PZT film.

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Hsien-Ming Lee whose telephone number is 703-305-7341. The examiner can normally be reached on M-F (9:00 ~ 5:00).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri can be reached on 703-306-2794. The fax phone numbers for the organization where this application or proceeding is assigned are 703-308-7722 for regular communications and 703-308-7722 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

Hsien-Ming Lee
Examiner
Art Unit 2823

May 19, 2003